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AERODYNAMIC TESTS OF AN M-31 BOMB IN THE 8-FOOT HIGH-SPEED TUNNEL

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NACA

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MEMORANDUM REPORT

for

Army Air Forces, Materiel Command

AERODYNAMIC TESTS OF AN M-31 BOMB IN THE 8-FOOT HIGH-SPEED TUNNEL

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INTRODUCTION

In connection with a study of the bomb flight path, the Materiel Command of the Army Air Forces requested the NACA to conduct aerodynamic tests of a 300-pound M-31 demolition bomb.

Force tests at angles of attack from -15° to 30° were made up to a Mach number of 0.725, which corresponds to a speed of 810 feet per second at sea level. These tests were made in the NACA 8-foot high-speed wind tunnel at Langley Memorial Aeronautical Laboratory.

SYMBOLS

V free-stream velocity, feet per second

ρ free-stream density, slugs per cubic foot

q free-stream dynamic pressure, pounds per square foot $\left(\frac{1}{2}\rho V^2\right)$

a velocity of sound in air, feet per second

M Mach number, V/a

D drag, pounds

L lift, pounds

M pitching moment measured about the point of support, inch-pounds

F maximum area of cross section of bomb, 0.707 square foot

l over-all length of bomb, 50.375 inches

α angle of attack of bomb, degrees

C_D drag coefficient, $\frac{D}{qF}$

C_L lift coefficient, $\frac{L}{qF}$

C_m pitching-moment coefficient, $\frac{M}{qFl}$

APPARATUS AND METHODS

The case of a 300-pound M-31 demolition bomb with aluminum fins was supplied by the Materiel Division for the tests. The bomb was supported on the tunnel center line by a single vertical streamline strut of NACA section 0009-64 (fig. 1). A streamline fairing shielded the vertical strut to within 11 inches of the bomb case. A side brace housed within a streamline fairing braced the vertical strut. Because additional lateral support was found necessary during the tests, two horizontal guy wires were attached at the point of support of the bomb. The vertical support strut, side brace, and stays were attached to the balance ring and were included in the force measurements.

The angle of attack was variable through fixed increments by means of an internal indexing mechanism. The bomb was rotated about its point of support, the center of gravity for the loaded condition.

TESTS

Lift, drag, and pitching moments were measured at angles of attack from -15° to 30° up to a Mach number of 0.725. These tests were run with the tail vanes set at an angle of 45° to the horizontal (fig. 2) in order to minimize the effect of the wake of the support strut on the tail. One run was made at the 5° angle of attack with the tail rotated 45°. Additional tests were made at 5°, 15°, and 30° angles of attack with the tail removed.

Tare forces on the strut were measured with the bomb guyed in position (fig. 3). Forces on the two side stays were determined by measuring the forces at zero angle of attack with and without stays.

RESULTS AND DISCUSSION

Figures 4, 5, and 6 show the drag, lift, and pitching-moment coefficients of the complete bomb at angles of attack from -15° to 30° through the speed range of the tests. It will be noted that the maximum speed of the tunnel was considerably reduced at the high angles of attack due to the large increase in drag at this attitude. All of the data presented have been corrected for tares. The magnitude of the tare forces for $\alpha = 0°$ is also shown in figures 4, 5, and 6 to give an indication of the probable accuracy of the bomb force data. The tare forces did not change appreciably with angle of attack.

Figure 7 is a cross plot of figure 6 showing the variation of pitching-moment coefficient with angle of attack for various Mach numbers. Figures 8, 9, and 10 show the drag, lift, and pitching-moment coefficients of the bomb without tail and the increments from the addition of the tail. Figure 11 is a photograph of the bomb tail after structural failure.

Drag. - The drag coefficient of the complete bomb for a range of positive and negative angles of attack is shown in figure 4. The tare drag for the model support is shown to be approximately one-half of the minimum bomb drag. Where corresponding positive and negative angles were run, the drag coefficients were approximately equal except for the 15° angles. At the high Mach numbers the drag for the negative angle, where the tail is well within the wake of the support strut, is less than the drag for the corresponding positive angle. In free air where no support strut interference is present, the drag for the negative angle would likely be the same as that for the positive angle.

At low angles of attack the critical speed of the bomb was reached at a Mach number of approximately 0.725 (fig. 5), a value which is higher than is usually obtained on streamline bodies of equivalent fineness ratio. In view of the very high drag coefficient of the bomb at the sub-critical Mach numbers, it appears that the flow over the bomb has separated. This separation has reduced the local velocities and therefore increased the critical speed.

Lift. - The lift coefficient remained essentially constant at low Mach numbers (fig. 5) but increased slightly at the higher speeds. This increase in the value of the lift coefficient corresponds to the shift in the pitching-moment-coefficient curve in magnitude and direction (fig. 6).

Pitching moment. - An analysis of the pitching-moment coefficient for a given angle of attack (fig. 6) shows a decrease at the high Mach numbers through the angle range from -15° to 20°. This decrease is not considered a compressibility effect but instead is believed to be an interference effect of the strut wake on the bomb tail. For the runs with the tail removed, the pitching-moment coefficient remained essentially constant through the Mach number range of the tests.

The moment decrease is most pronounced at the negative angles of attack where the bomb tail is in the wake of the support strut and fairing. The magnitude of the pitching-moment-coefficient increments due to the addition of the tail (fig. 10) indicates that a change in load on the tail equivalent to a $1\frac{1}{2}^{\circ}$ change in angle of flow would be sufficient to account for the maximum moment

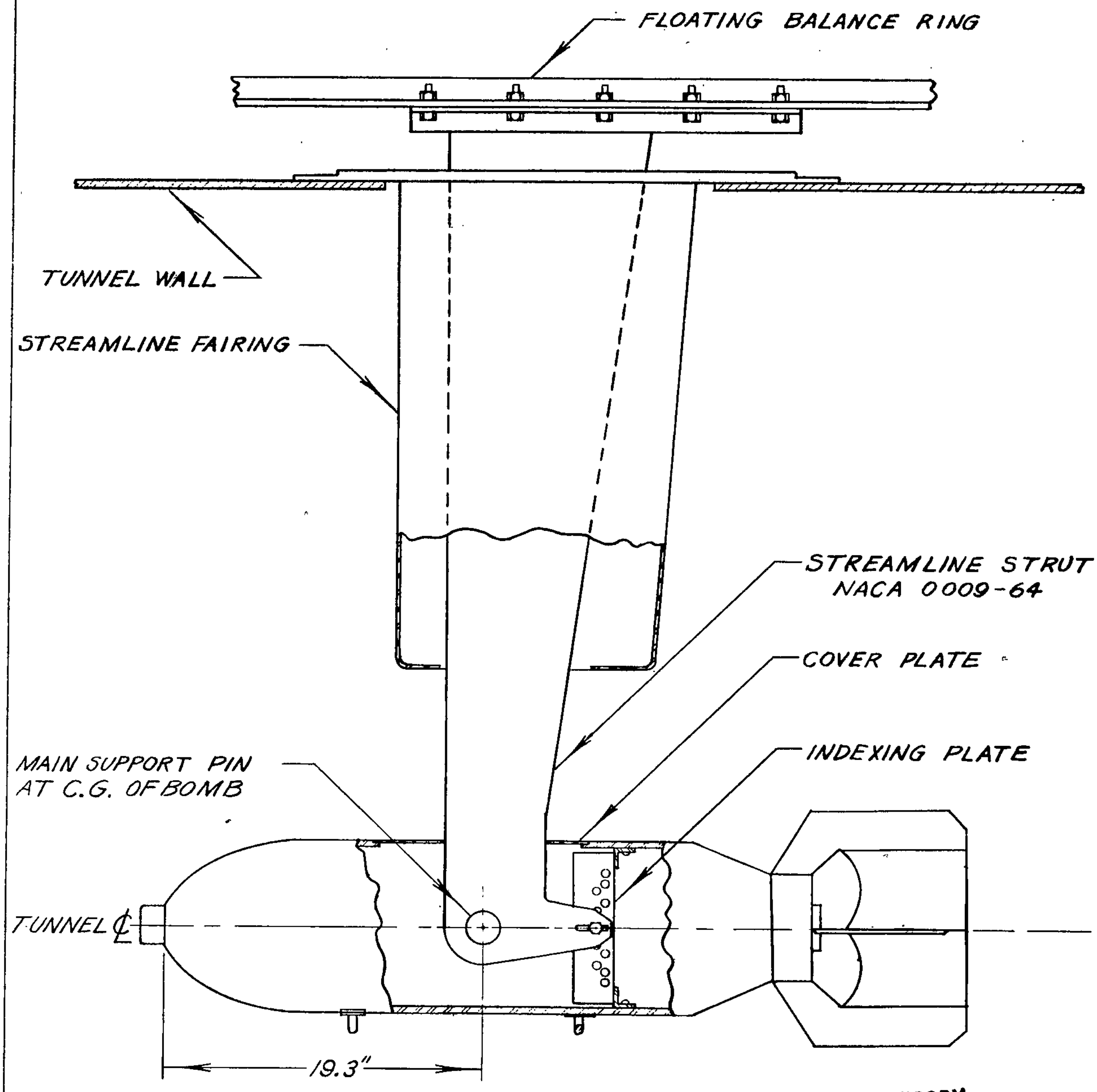

Figure 1.- Installation details of M-31 bomb.

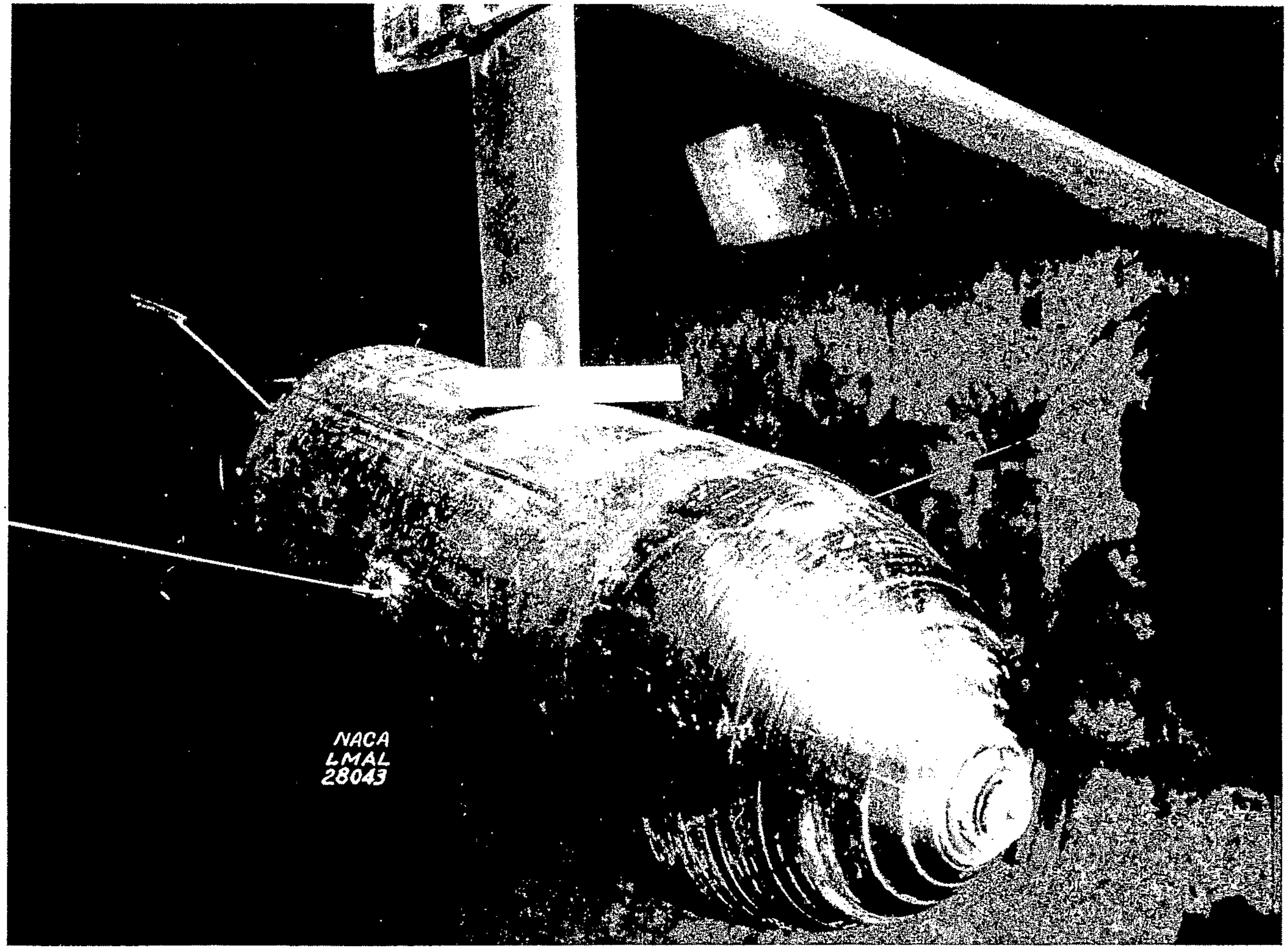

Figure 2.- General view of M-31 bomb.

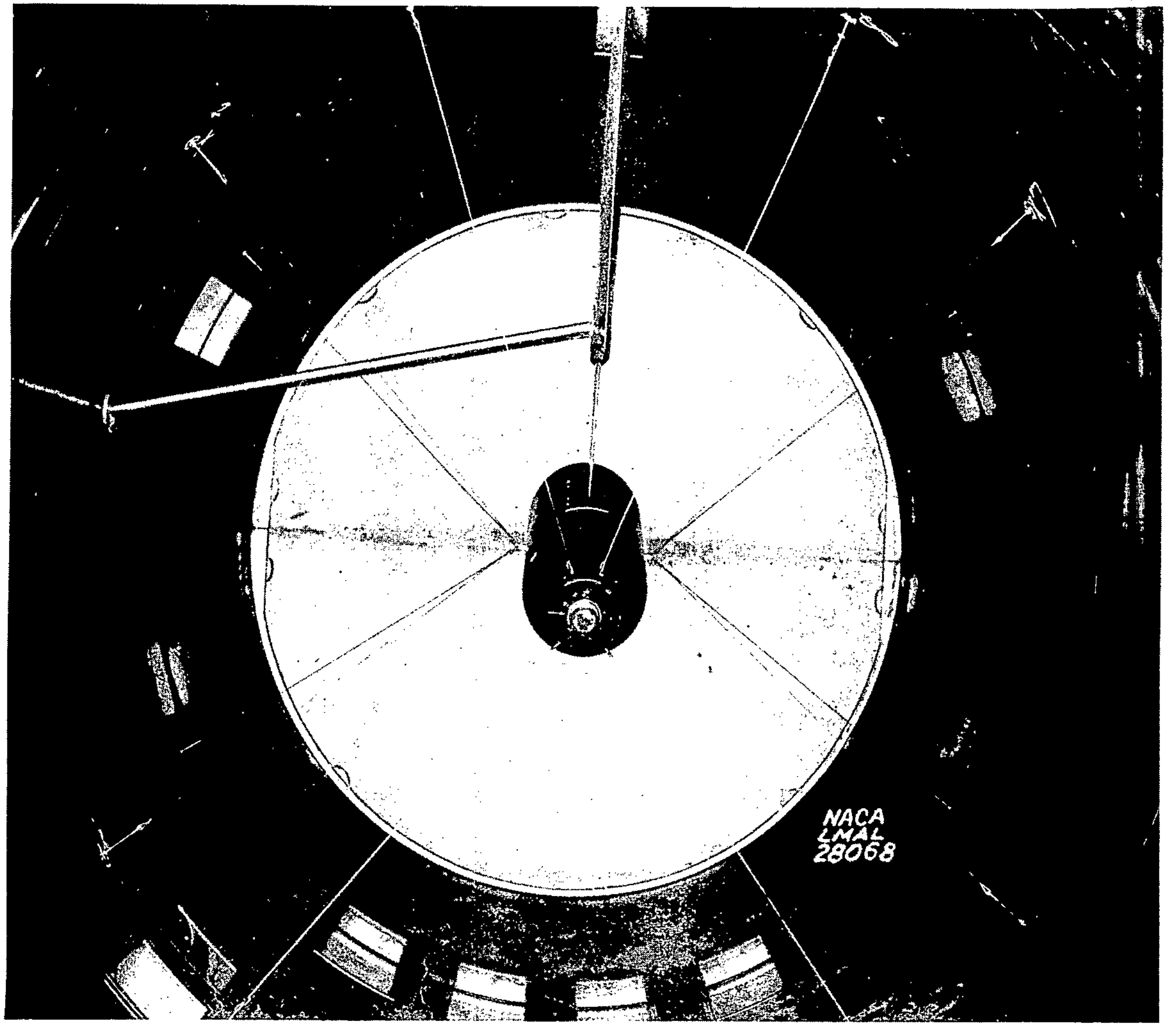

Figure 3.- Tare set-up for M-31 bomb.

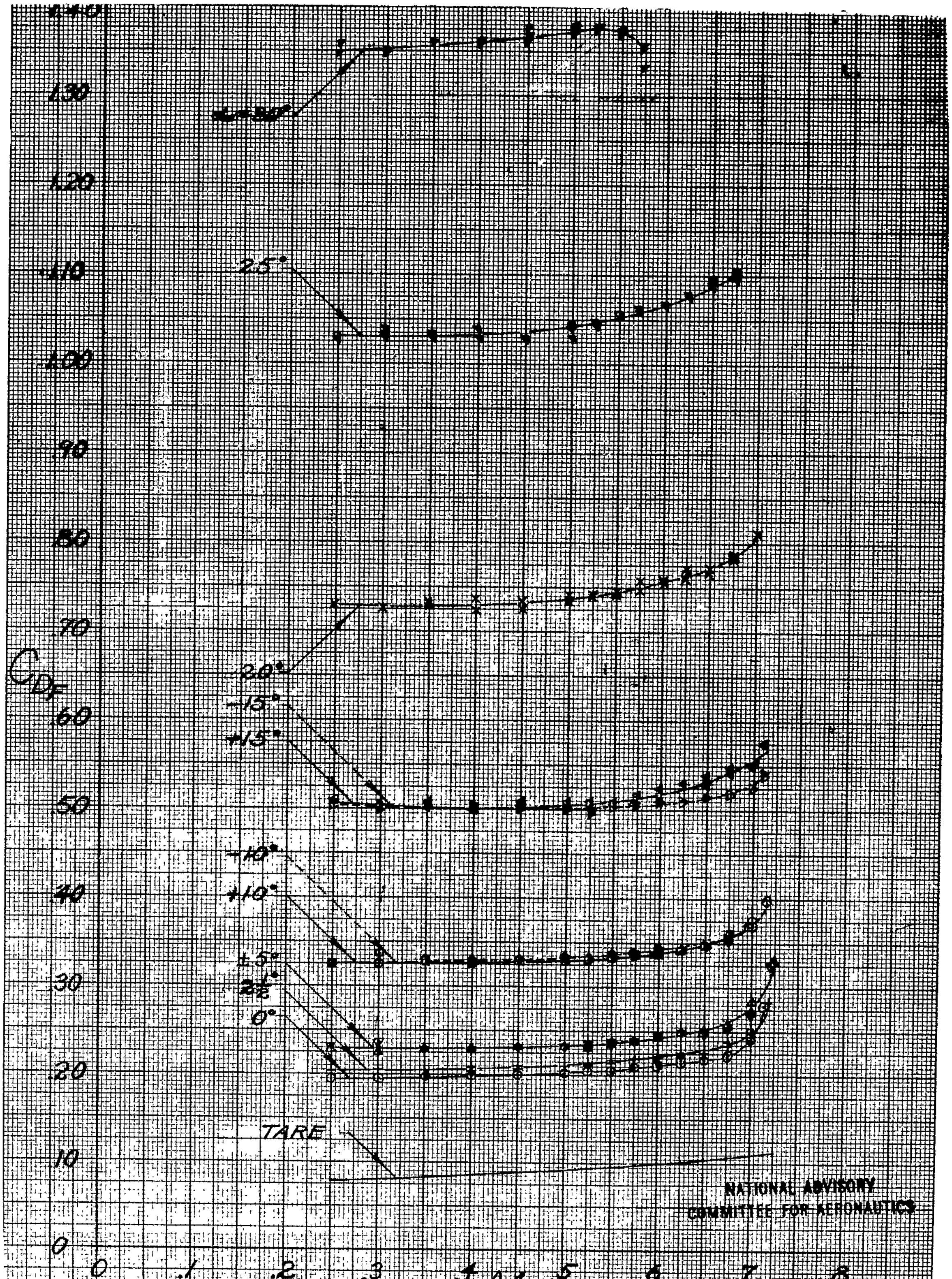

Figure 4.- Variation of drag coefficient with Mach number for various angles of attack.

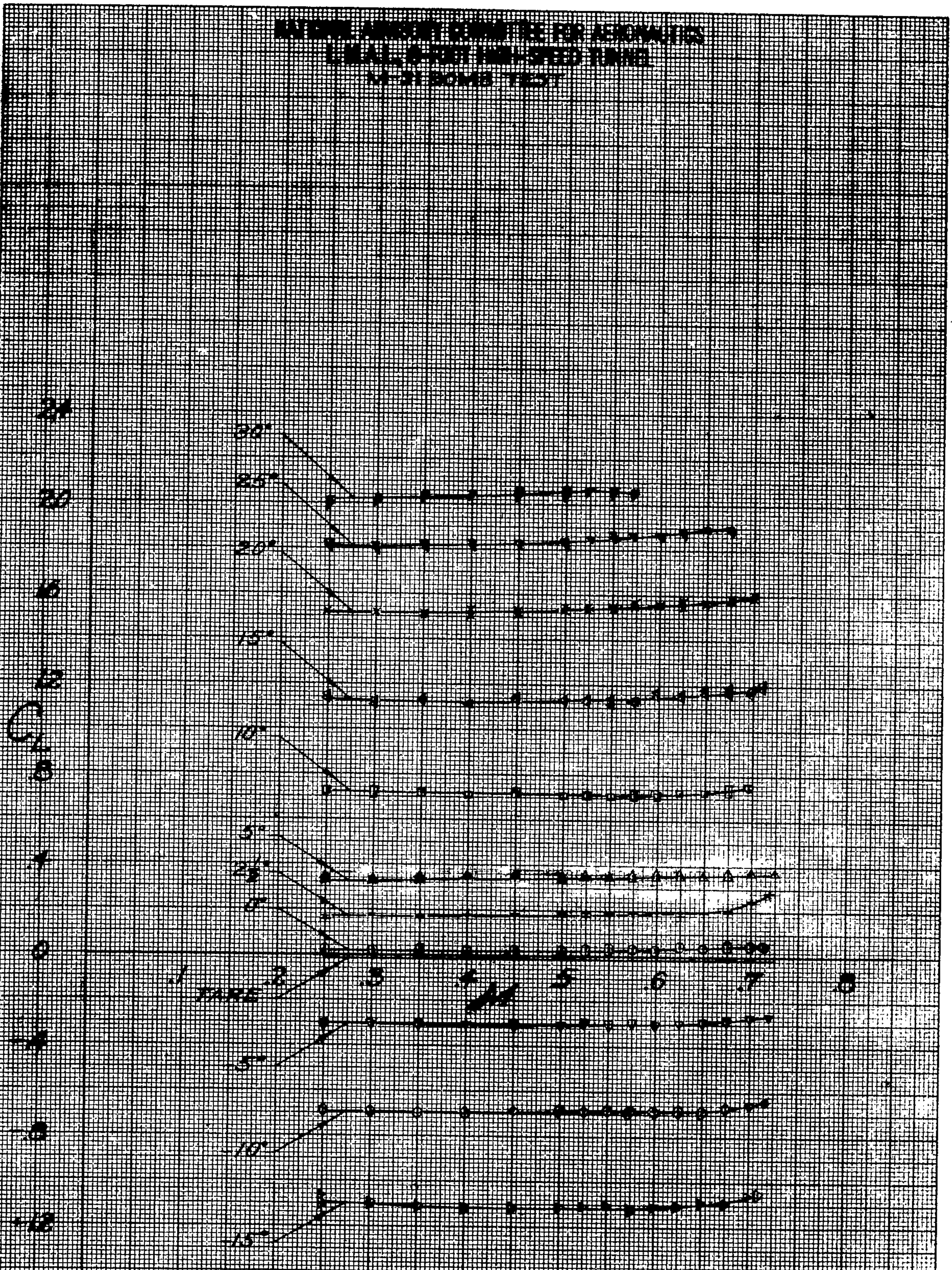

Figure 5.- Variation of lift coefficient with Mach number for various angles of attack.

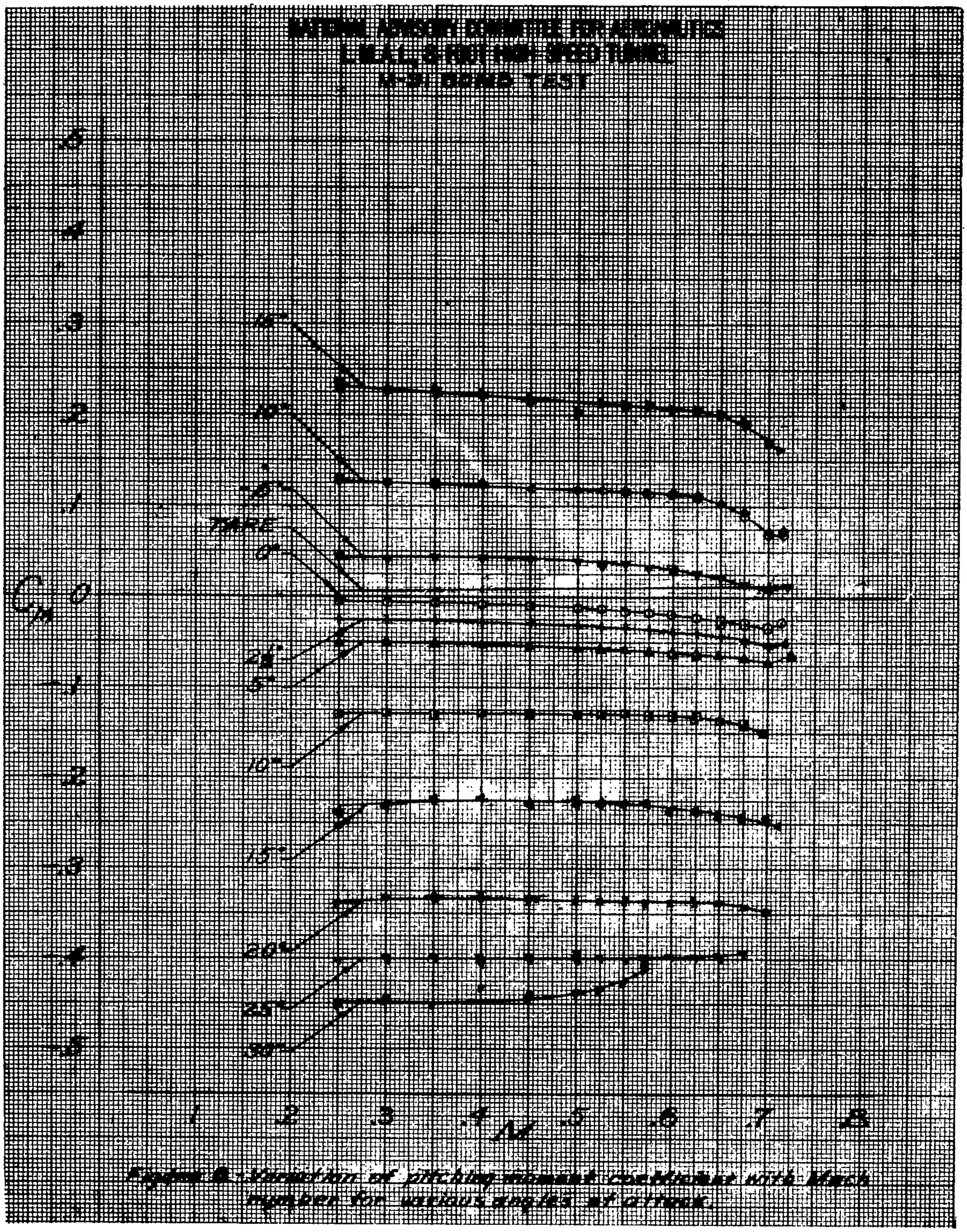

Figure 8.- Variation of pitching moment coefficient with Mach number for various angles of attack.

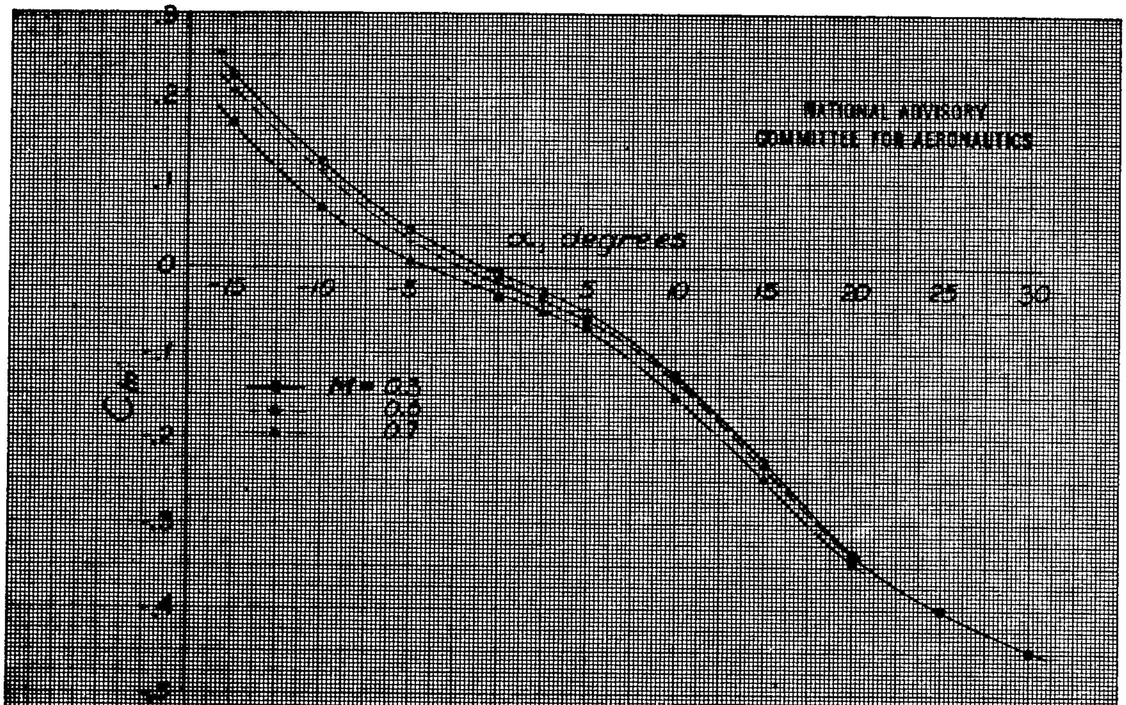

Figure 7.- Variation of pitching-moment coefficient with angle of attack for various Mach numbers.

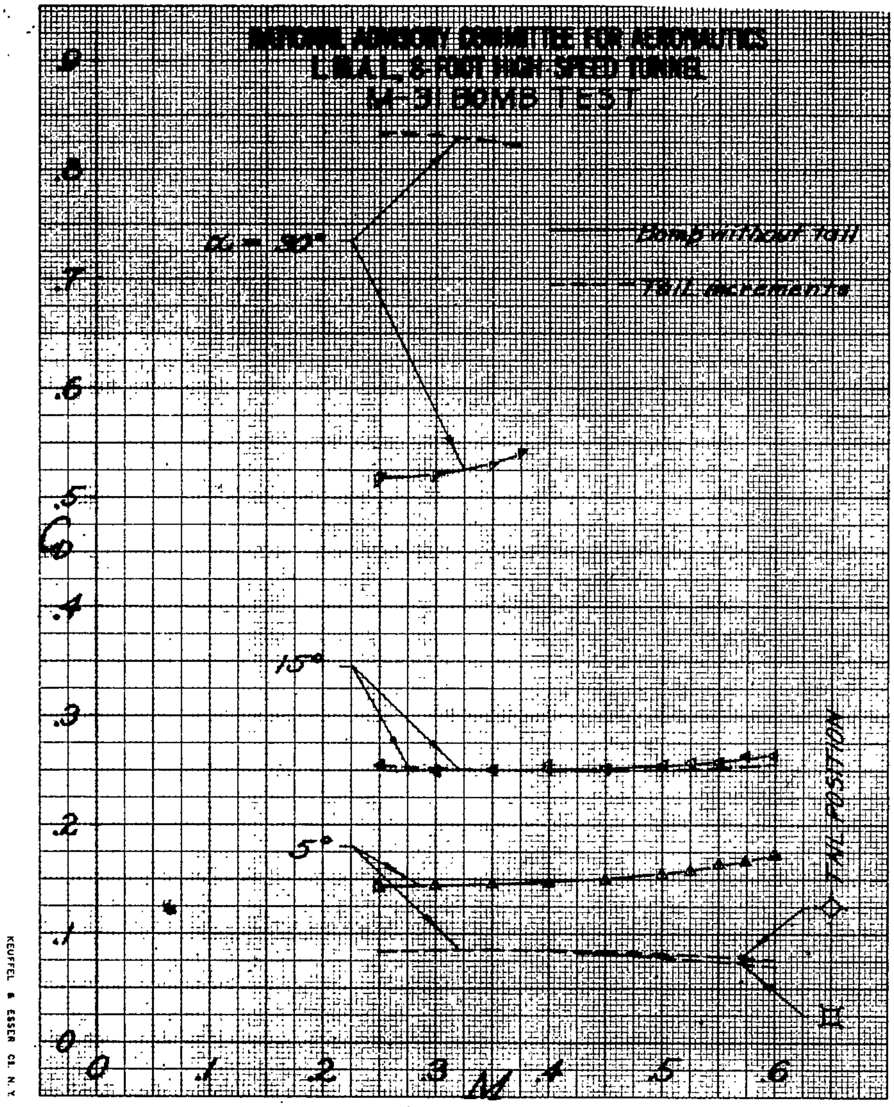

Figure 8.- Variation of tail and bomb case drag with Mach number.

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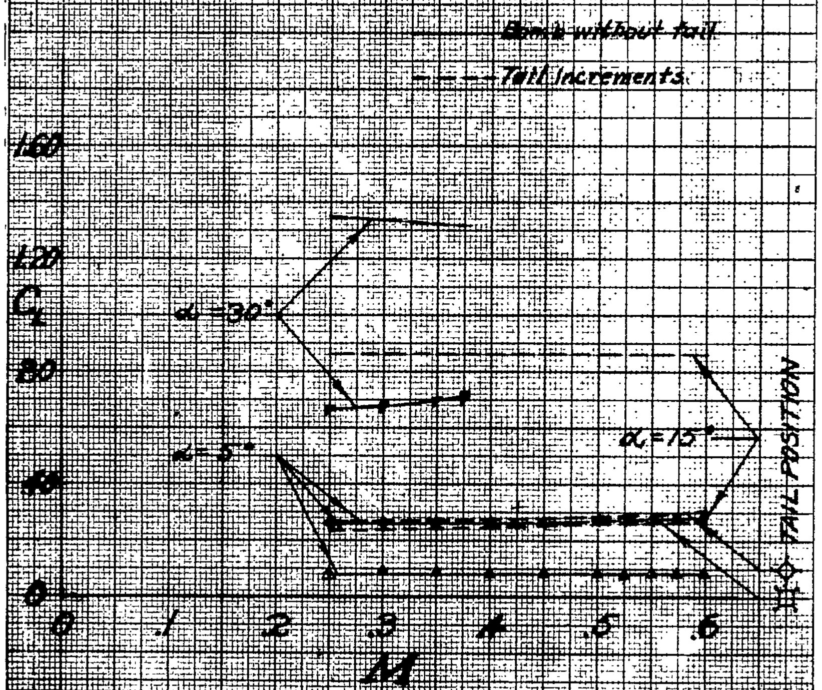
Figure 9 - Variation of tail and bomb case lift with Mach number.



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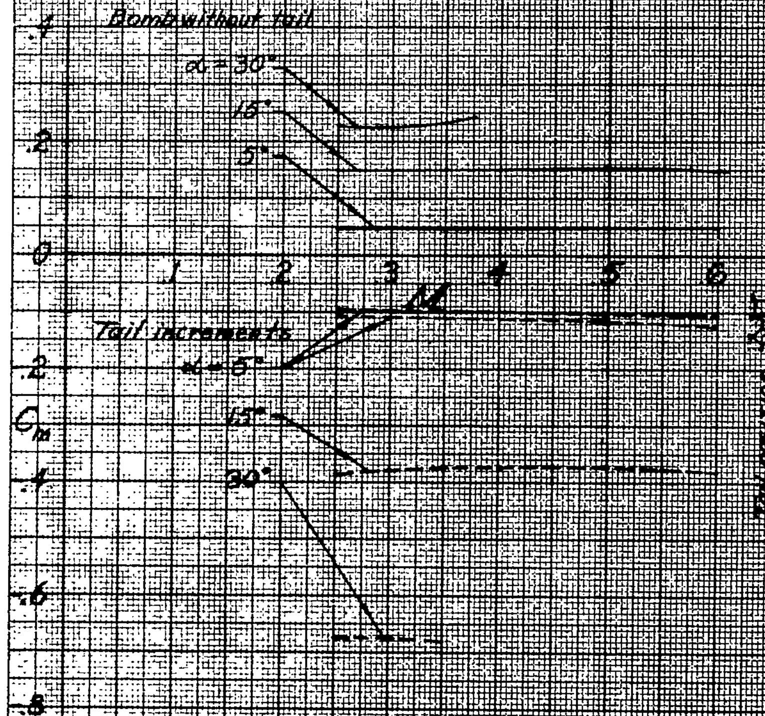

Figure 10 - Variation of tail and bomb case pitching moment with Mach number.

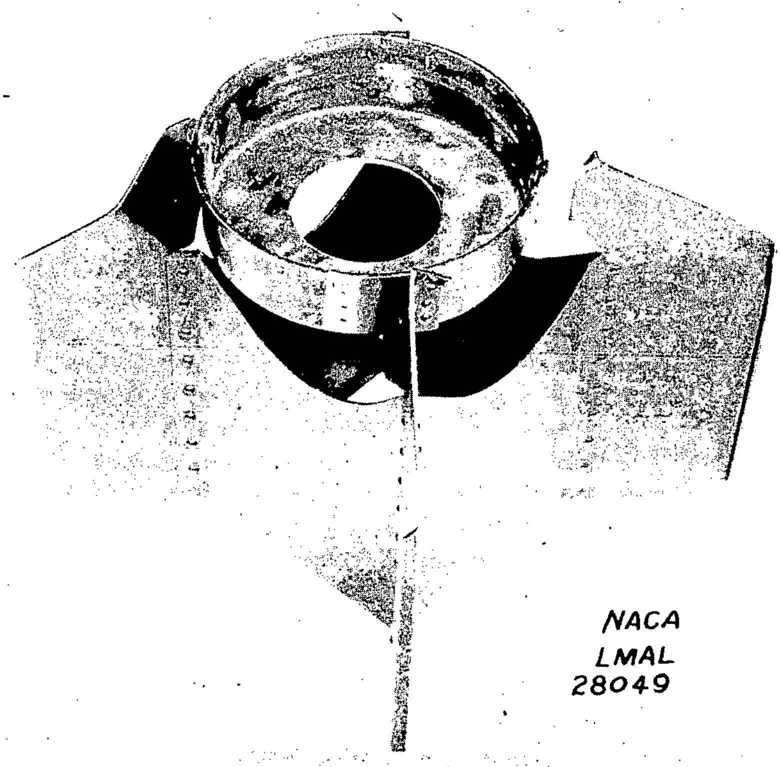

Figure 11.- M-31 bomb tail showing structural failure.